DOCUMENT RESUME

ED 177 856 FL 010 461

AUTHOR Tobin, Aileen Webb; Venezky, Richard L.
TITLE The Effect of Orthographic Structure on Letter Search: An Attempt to Replicate and Extend Previous Findings.
PUB DATE 79
NOTE 26p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Francisco, CA, April 1979)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Language Processing; *Language Research; Letters (Alphabet); *Orthographic Symbols; *Perception Tests; *Research Design; Structural Analysis; *Verbal Learning; *Visual Perception; Visual Stimuli; Word Recognition

ABSTRACT

A previous study by Gibson et al. (1972) that investigated the effect of orthographic structure on letter search was replicated and extended in order to identify factors that might explain the apparent discrepancy between their results and those of comparable studies. Experiment one tested whether the discrepancy might be explained by difference in (1) the sensitivity of a between-subjects design as opposed to a within-subjects design, or (2) the overall range of orthographic structure represented in the displays, when subjects have been equated in terms of their rate of search through random strings of consonants. Experiment two was concerned with the psychological reality of the differences in the orthographic structure of the letter strings presented in experiment one. In comparing the results of the two analyses of the search time data, it might be argued that the negative findings of the Gibson et al. study may be explained by the nature of the constraints they adopted in constructing their orthographically well-structured and poorly structured strings. It is suggested that unlike the more traditional, between-subjects design, a within-subjects design permits subjects to compare differences in orthographic structure. This encourages them to adopt more efficient search strategies for strings having more than a minimum amount of structure. (SW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED177856

Session No.: 1.21

THE EFFECT OF ORTHOGRAPHIC STRUCTURE ON LETTER SEARCH: AN ATTEMPT TO REPLICATE AND EXTEND PREVIOUS FINDINGS

Aileen Webb Tobin
Richard L. Venezky

University of Delaware

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Aileen W. Tobin

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, April, 1979.

FL010461

THE EFFECT OF ORTHOGRAPHIC STRUCTURE ON LETTER SEARCH: AN ATTEMPT TO REPLICATE AND EXTEND PREVIOUS FINDINGS[1]

Aileen Webb Tobin and Richard L. Venezky[2]

University of Delaware

Within the field of cognition and perception, there is an increasing amount of literature which maintains that an entity referred to as orthographic regularity plays a central role in word recognition. However, it is also apparent that there is little, if any, consensus as to how this construct should be defined (Venezky & Massaro, 1979) or why it seems to facilitate letter search in some instances (Baron, 1974, Exp. IV; Krueger, 1970, Exp. III; Krueger, Keen, & Rublevich, 1974, Exp. I; Krueger & Weiss, 1976, Exp. I; Lefton, 1974, Exp. III, IV, & V; Mason, 1975, Exp. II) but not in others (Gibson, Tenney, Barron, & Zaslow, 1972). Unlike other investigators who have compared the speed of letter search through orthographically well-structured and poorly structured letter strings, Gibson et al. found that subjects searched as quickly through poorly structured strings as they did through well-structured ones. Two of the most plausible explanations that have been offered to account for this discrepancy are both concerned with the fact that Gibson et al. adopted a between rather than a within-subjects experimental design. Gibson and her colleagues suggested that their adoption of the more traditional design may have prompted their subjects to use a strategy that was significantly different from the one they might have adopted had each of them been given the opportunity to search through both orthographically well-structured and poorly structured displays. On the contrary, Krueger and Weiss (1976) proposed that the negative findings reported by Gibson et al. might well

have been a function of the fact that the subjects who were assigned the orthographically well-structured displays also happened to be those who would have had the slower overall search times regardless of the nature of the displays.

However, in addition to the possibility that the results of the Gibson et al. study might be explained in terms of the particular experimental design they chose to adopt, it also seems likely that their results may have been a function of the constraints they used in generating their stimuli. Although the item construction procedures used in studies on orthographic structure have not been based on a uniform set of constraints, those adopted by Gibson et al. were unique in that they were subject to the restriction that the poorly structured items should conform to the consonant-vowel (CV) patterns found in the well-structured strings. Thus, while the orthographically well-structured (OS) and poorly structured (NS) strings presented in the Gibson et al. study may have differed in terms of their adherence to the various constraints and conventions of the English language, this difference may not have been sufficient to have had any psychological reality. In any case, an inspection of the items used in their study indicates that the poorly structured strings had a considerable amount of local regularity, i.e., approximately 36% had an acceptable CVC sequence, and another 26% acceptable CVVC, CCVC, or CVCC sequences.

The purpose of the present study was to determine if the Gibson et al. study could be replicated and, if so, what factors might explain the apparent discrepancy between their results and those of comparable studies. Experiment I (Exp. I) tested whether the discrepancy might be explained by differences in (a) the sensitivity of a between as opposed to a within-subjects design or (b) the overall range of orthographic structure represented

in the displays, when subjects have been equated in terms of their rate of search through random strings of consonants. Experiment II (Exp. II) was concerned with the psychological reality of the differences in the orthographic structure of the letter strings presented in Exp. I and will be discussed further below.

Experiment I

Method

Subjects. Seventy-five undergraduates served as subjects in Exp. I. However, one subject experienced a hardware problem with the display system and was, therefore, excluded from the analysis of the data. All subjects had 20/30 vision (corrected) or better and indicated that English was their native language.

Stimulus materials. Search displays were constructed by sampling from four pools of five-letter items: (a) a pool of 300 random strings of consonants (RSC) to be used as context items; (b) a pool of 100 RSC target items; (c) a pool of 60 orthographically structured (OS) context items paired with their corresponding nonstructured (NS), orthographically irregular but maximally structured (OI-MAX), and orthographically irregular and minimally structured (OI-MIN) strings; and (d) an analogous pool of 20 sets of OS, NS, OI-MAX, and OI-MIN target items.

The OS items were those used by Gibson et al. The OS items were pronounceable pseudowords, and the NS items their anagrams. Forty percent of the OS items had a CCVCC pattern, and the remaining 60% were evenly distributed across CVCCC, CVVCC, and CCVVC. Although Gibson et al. indicated that each NS item was constructed subject to the restrictions that it should have a CV pattern identical to its corresponding pseudoword but fail to conform to the graphemic conventions and phonological constraints

of the English language, they did not adhere to the former restriction when constructing the NS anagrams for OS items having a CVCCC pattern since each of these anagrams had a CCCVC pattern. Thus, 40% of the NS items had a CCVCC pattern, and the remaining 60% were evenly distributed across CCCVC, CVVCC, and CCVVC.

The RSC items were random strings of consonants, none of which contained more than one occurrence of any given letter; the OI-MAX items, anagrams of the OS strings constructed subject to the constraint that each should be orthographically irregular but contain a maximum amount of local structure (i.e., an orthographically acceptable four-letter sequence); and the OI-MIN items, anagrams of the OS strings constructed so as to have a minimum amount of local regularity. In addition, construction of the OI-MAX items was subject to the restriction that the position of their orthographically structured four-letter sequences should be counterbalanced to distribute the vowels over as many of the five letter positions as possible. As a result, OI-MAX items having only one vowel were constructed so that their structured sequences would be evenly distributed over each of the following CV pattern-serial position combinations: CVCC, positions 1 through 4; CVCC, positions 2 through 5; CCVC, positions 1 through 4; and CCVC, positions 2 through 5. Similarly, while the orthographically regular sequences in OI-MAX items having two vowels were necessarily confined to a CVVC pattern (due to the constraints inherent in the nature of the OS items), 50% of these items were constructed so that their structured sequences would fall in positions 1 through 4, and the remainder were constructed so that their structured components would occupy positions 2 through 5. Although it was impossible to eliminate local regularity completely in the OI-MIN items, none had an orthographically acceptable sequence of more than three

letters or a summed bigram count exceeding 6 as measured by the Mayzner, Tresselt, and Wolin (1965) tallies for five-letter words. Half of the OI-MIN items containing only one vowel had a VCCCC pattern, and the remainder a CCCCV pattern. Similarly, 50% of the OI-MIN items containing two vowels had a VVCCC pattern, and the other 50% a CCCVV pattern.

A single target letter (N) was used in all trials. None of the context items contained the target letter, and each of the target items contained one and only one occurrence of the target letter. All five types of target items were constructed so that the position of the target letter was evenly distributed across all five serial positions, and the N in each set of OI-MAX, NS, and OI-MIN target items occupied the same serial position as the one it assumed in the corresponding OS item.

A total of 180 experimental displays were generated and stored on the University of Delaware's PLATO system. Each display consisted of a list of 30 items displayed in a single column, single spaced, and centered on a PLATO plasma display screen. All items were displayed in upper-case letters. With two exceptions (I = 2.03 mm. X 3.66 mm., and Q = 2.85 mm. X 4.47 mm.), each letter was 2.85 mm. wide and 3.66 mm. high. Letters were displayed 1.22 mm. apart, and each five-letter string subtended a horizontal visual angle of 2°12′ and a vertical angle of 0°36′. One hundred displays contained RSC items, and 20 contained OS, OI-MAX, NS, and OI-MIN strings, respectively. One item in each RSC display was sampled without replacement from the pool of RSC target items, and each of the remaining strings was sampled from the corresponding pool of context items. Sampling of the context items was subject to the constraint that in no instance should a given item appear twice in the same display or in two successive displays. The position of the target item was restricted to rows 5 through 28 and randomly determined for

each RSC display; context items were randomly assigned to the remaining positions. Although similar procedures were used in constructing each of the other four types of displays, provisions were made to ensure that each of the OI-MAX, NS, and OI-MIN displays had an OS counterpart and that the target item appeared in a different position in each set of four corresponding displays.

Procedure. Subjects were required to attend two experimental sessions, scheduled no less than 13 days and no more than 19 days apart. At the beginning of each session, subjects were told that it would be their task to find the letter N in each of several lists of five-letter items to be displayed one list at a time on the PLATO terminal before them. They were instructed to search as quickly as possible but not at the expense of accuracy, starting at the top and proceeding down each list. They were also told that they should press a designated key on the terminal keyboard (a) as soon as they had found the N or (b) if they had scanned through the entire list and failed to find the target. Subjects were instructed not to backtrack but to make only a single scan down each list.

The onset of each trial was controlled by the subject, and a verification display (i.e., a 30 X 5 matrix of X's occupying the same area of the screen as the search displays) was presented at the end of each trial to determine if the subject had actually located the target letter. When the verification display appeared, the subject was to indicate the position of the item containing the letter N in the previous display by touching the appropriate row of X's on the screen. If the subject did not find the N in the previous display, s/he was to touch the phrase "Did not find N" which appeared in a circle to the right of the column of X's; as soon as the subject did so, the verification display was replaced with a

fixation point. This point occupied the same position as the third letter of the first item in each of the search displays and appeared on the screen before the onset of each of the search displays. However, if the subject touched one of the rows of X's, the circle disappeared and was replaced with a box containing the words "Touch here to store your response." In addition, both a pair of arrows pointing to the row of X's the subject had indicated and two additional boxes, one containing the words "Touch here to move the arrows higher" and the other, the words "Touch here to move the arrows lower", appeared on the screen. By touching either or both of these boxes, the subject was able to change the position of the arrows and, thus, modify his/her response. Once the desired adjustments were made, the subject pressed the "storage" box, and the display was replaced with a fixation point indicating that a new trial would begin as soon as the subject signalled the onset of another search display. In addition to the verification data, reaction times were automatically recorded and stored by the PLATO system.

Each subject searched through 80 RSC displays in the first experimental session and all remaining displays in the second session. The first 20 displays presented in both sessions were considered practice trials. Although consistent across subjects in the first session, the order of presentation was varied in the second session so that each of the four sets of corresponding OS, OI-MAX, NS, and OI-MIN displays occurred equally often as Blocks 2, 3, 4, and 5. Subjects were randomly assigned to one of the 24 possible permutations subject to the constraint that the four groups of subjects assigned different sets of Block 2 displays had similar mean search rates on the last 60 displays presented in the first experimental session.

Data analysis. As originally planned, all RSC and error trials were removed before the search time data were analyzed. Error trials were defined

as: (a) those in which the subject indicated that s/he did not find the target letter (DNF trials); and (b) those where the absolute value of the difference between the row in which the target item appeared and the row in which the subject indicated s/he found the target letter was larger than 1 (Line Error trials). However, once these trials were eliminated, an inspection of the plotted search rates across the "valid" trials for each subject in each of the four corresponding blocks of OS, OI-MAX, NS, and OI-MIN displays suggested that there were obvious outliers in the data, and based on informal observations of the subjects' overt behavior while collecting the data, it seemed reasonable to assume that these "outliers" represented at least one additional source of error. In brief, the assumption was that they might be explained by: (a) the subjects' general tendency to backtrack through the search displays rather than indicate that they had failed to find the target letter; and (b) the possibility that some of the subjects occasionally neglected to begin their search from the top of the displays and, as a result, were sometimes fortunate enough to spot the target item almost immediately. Thus, when Barlett's test for equality of variances yielded a significant Chi Square statistic ($p<.05$) for 53 of the 74 subjects to be included in the analysis of the data, several strategies were adopted to eliminate any statistically significant outliers.

First, the four plots of "valid" trials for each of the subjects for whom the assumption of equal variances was rejected were reexamined. Of the 53 subjects falling in this category, five had extremely large within-subjects variances and no apparent outliers; in addition, their data seemed inconsistent with that of the rest of the sample which, aside from a few apparent outliers, generally had relatively stable search rates across the trials of any given block of displays. Consequently, it was assumed that

each of these five subjects was not representative of the population sampled, and they were excluded from all subsequent analyses. Of the remaining 48 subjects having unequal within-subjects variances, each had at least one outlier in one or more of the four relevant blocks of displays, and their data were subsequently tested in one of three ways.

1. If the subject seemed to have outliers in only one or two blocks of trials, McKay's test (1935) was performed on the trials in question, using an alpha of .05 and the mean variance of the blocks having no apparent outliers as the pooled estimate of variance. Although technically this procedure is only designed for one outlier, it was reapplied as a first approximation for the identification of any additional outliers.

2. If the subject seemed to have no more than two outliers in each of three or four blocks of trials, Grubbs's test (1950) was performed on the trials in question, using an alpha of .05.

3. If the subject seemed to have no more than two outliers in each of two or three blocks of displays but more than two outliers in another block, Grubbs's test was performed on the trials questioned in the blocks having no more than two trials to be tested ($p<.05$), and McKay's test was performed on the trials in question from the remaining block ($p<.05$). In this instance, McKay's test was also reapplied as a first approximation for the identification of all probable outliers; however, the pooled estimate of variance was based on the variances of the three other blocks once the outliers identified by Grubbs's procedure were eliminated.

Outliers identified by either of these tests were defined as error trials and, therefore, also excluded from analyses of the search time data. Levene's test for homogeneity of variances was then performed on the data retained for analysis. The results were insignificant, $F(15,260) = .50$, $p>.05$, and

it was assumed that the data to be analyzed met the assumptions underlying an analysis of variance.

Results

To determine if the results of the Gibson et al. study had been replicated, the data relevant to the second block of trials in the second experimental session were entered into a stepwise regression analysis. This regression procedure was comparable to a one-way analysis of variance having type of display (OS, OI-MAX, NS, OI-MIN) as the independent variable and mean rate of search (measured in msec. per line) as the dependent variable. Replicating the original study, display type had an insignificant effect, $F(3,65) = .27$, $p > .05$, and functioned to explain less than 2% ($R^2 = .0124$) of the variance in the rate of search.

However, when a within as opposed to a between-subjects analysis was performed on the search time data, the results were somewhat different. Using a stepwise regression procedure that was analogous to a 4 (type of display: OS, OI-MAX, NS, OI-MIN) by 4 (block number: 2, 3, 4, 5) analysis of variance with repeated measures, each of the main effects was found to be significant. Display type, block number, and the coded vectors representing the subjects yielded F ratios of $F(3,192) = 5.27$, $p < .01$; $F(3,192) = 31.58$, $p < .01$; and $F(68,192) = 44.17$, $p < .01$, respectively. When the contribution of the other main effects were taken into account, display type functioned to explain .48%, block number 2.86%, and the subject vectors 90.6% of the variance in rate of search. The interaction of Display Type and Block Number was insignificant, $F(9,192) = 1.24$, $p > .05$, and explained only .33% of the variance in the dependent variable once adjustments were made to take into account its correlation with the main effects. Although subjects searched significantly faster through OS as opposed to OI-MIN displays

($p < .05$), all other post hoc comparisons of the search rates for the four types of displays yielded an insignificant |D| score. On the contrary, all but one (i.e., Block 3 vs. Block 4) of the post hoc comparisons of mean search rate over the four blocks of trials were significant at the .05 level and, with the exception of the difference between the means for Blocks 2 and 3, also significant at the .01 level. The mean search rates for each cell of the analysis and each level of display type and block number are shown in Table 1.

- - - - - - - - - - - - - - -

Insert Table 1 about here

- - - - - - - - - - - - - - -

Analogous regression analyses using total error rate as the dependent variable suggested no speed-accuracy tradeoffs. Aside from the contribution of the coded subject vectors, $F(68,192) = 2.89$, $p < .01$, neither of the error analyses identified any significant effects. DNF, Line, and Outlier error

- - - - - - - - - - - - - - -

Insert Table 2 about here

- - - - - - - - - - - - - - -

rates for each type of display are shown in Table 2.

Experiment II

In light of the results of Exp. I, it might seem reasonable to assume that the adult reader is largely unaware of subtle differences in orthographic structure. To determine if this assumption could be supported and to ascertain the validity of measuring orthographic structure in terms of local regularity, subjects participating in Exp. II were asked to rate each of the OS, OI-MAX, NS, and OI-MIN strings used in Exp. I based on the extent to which they looked like an English word.

Method

Subjects. Eighty-eight undergraduates served as subjects in Exp. II, but four were excluded from the analysis of the data. Two subjects failed to complete the rating protocol; one indicated that she failed to tell the investigators that English was not her native language when she volunteered to participate; and one was randomly eliminated to equalize the number of subjects in each cell of the analysis. With the exc tion of the subject referred to above, all subjects indicated that English was their native language.

Stimulus materials. Four alternate forms of a four-page rating protocol were prepared for use in Exp. II. Each form listed all of the OS, OI-MAX, NS, and OI-MIN items displayed in Exp. I. Items were listed in random order, and the forms differed only in terms of the order in which the items were presented. Eighty items were presented on each page, and each page was divided into four columns of equal length. All items were typed in upper-case Elite script using an IBM Selectric typewriter, and each item was followed by a blank for purposes of recording its numerical rating. Written directions to the subjects were printed on a separate sheet of paper and attached to the front of each protocol. The rating scale described and displayed in the directions was reproduced at the top of each page.

Procedure. Each subject was randomly assigned one of the four alternate forms of the rating pr tocol. The directions were read aloud to the subjects and similar to those described in Underwood and Schulz (1960). Subjects were given a 9-point rating scale and instructed to assign high numbers to those strings that looked most like an English word and low numbers to those strings which looked least like an English word. They

were also told that they would be expected to use each of the numbers on the scale and that they should end up with roughly the same number of strings in each category.

Results

When the subjective ratings were analyzed using a regression procedure comparable to a 4 (string type: OS, OI-MAX, NS, OI-MIN) by 4 (form: 1, 2, 3, 4) analysis of variance with repeated measures on the first factor, it was found that string type had a highly significant effect, $F(3,240) = 1301.32$, $p<.01$. Although the coded subject vectors also made a significant contribution, $F(80,240) = 7.35$, $p<.01$, neither form, $F = 0$, nor the interaction of String Type and Form, $F(9,240) = 1.36$, $p>.05$, had a significant effect. When the contribution of the other main effects were taken into account, string type explained 81.77%, form 0%, and the subject vectors 12.32% of the variance in ratings. Once adjustments were made to take into account its correlation with the main effects, the interaction of String Type and Form explained less than 1% ($R^2 = .0026$) of the variance in the dependent variable. The rank order of the mean ratings for the four types of strings was positively correlated with the amount of local orthographic structure represented in the strings: OS, $\bar{X} = 7.527$; OI-MAX, $\bar{X} = 4.432$; NS, $\bar{X} = 3.172$; and OI-MIN, $\bar{X} = 2.264$. All post hoc comparisons were highly significant ($p<.01$), suggesting that subjects can clearly distinguish between strings of letters having different amounts of local regularity.

General Discussion

Comparing the results of the two analyses of the search time data, one might argue that the negative findings of the Gibson et al. study may be explained quite simply by the nature of the constraints they adopted in

constructing their orthographically well-structured and poorly structured strings. Although both analyses yielded a faster rate of search through OS as opposed to NS strings, the difference was not statistically significant in either analysis. Thus, as previously hypothesized, it appears that the orthographic differences in the two types of strings were not sufficient to have had any substantive influence on the subjects' rate of search.

In addition, it might be argued that the results of these analyses tend to support the explanation Gibson et al. proposed when attempting to come to terms with the discrepancy between their findings and those of other studies comparing the speed of search through orthographically well-structured and poorly structured strings. Although there is no evidence to suggest that the discrepancy might be explained solely in terms of the fact that Gibson and her colleagues adopted a less statistically powerful design, a comparison of the two analyses does suggest that subjects are much more sensitive to differences in orthographic structure when they are given the opportunity to search through both well-structured and poorly structured strings. In short, the suggestion is that unlike the more traditional, between-subjects design, a within-subjects design permits subjects to compare differences in orthographic structure which, in turn, encourages them to adopt more efficient search strategies for strings having more than a minimum amount of structure. This explanation is supported in two distinct ways: (a) the overall differences in the orthographic structure of the displays had a significant effect on the subjects' rate of search in the repeated measures analysis but failed to achieve significance in the analysis of non-repeated measures, despite the fact that the mean rate of search through OI-MIN displays did not appear to be significantly different in the two analyses; and (b) the overall

mean rate of search through each of the three sets of moderately well structured displays (OS, OI-MIN, and NS) appeared to be substantively faster in the repeated measures analysis.

However, it might also be argued that a within-subjects design yields somewhat different results from the more traditional, between-subjects design because it provides subjects with more of an opportunity for overall task improvement. Although the post hoc comparisons of the mean rate of search over blocks of trials seem to support this explanation, an inspection of the improvement curves shown in Figure 1 indicates that the mean rate of search through OI-MIN displays decreased over the first three blocks of

- - - - - - - - - - - - - - - - -

Insert Figure 1 about here

- - - - - - - - - - - - - - - - -

trials and, therefore, has a slope that cannot be explained on the basis of a general practice effect.

In fact, it seems that these improvement curves suggest yet another explanation. They appear to be more consistent with the hypothesis that the differences in the results of the two analyses of the search time data might be a function of a priming effect similar to that found in lexical decision and letter probe tasks (e.g., Aderman & Smith, 1971; Carr, Davidson, & Hawkins, 1978; Manelis, 1974; Rouse & Verinis, 1962) than either a comparison-facilitation or overall-task-improvement hypothesis. In brief, the suggestion is that the type of search strategy the subjects adopted in response to the displays presented in any given block of trials may have been influenced (i.e., primed) by the nature of the displays they had previously searched. This would explain the limited range of the search rates across the various types of displays reported for Block 2.

Assuming that the subjects were primed to continue to search through random strings of consonants, one would expect them to retain the search strategy they had found to be most effective in locating the target letter in RSC displays. Such a strategy could not be expected to facilitate their search through the more structured strings since it is likely that it was based on a letter by letter search and did not rely on the orthographic redundancy of the English language as a means of reducing the necessity of completely resolving each letter. In addition, this hypothesis would account for the overall differences in the slopes of the curves for the more structured (OS, OI-MAX, and NS) as opposed to the least structured (OI-MIN) displays. Assuming that the strategies the subjects adopted were influenced by their experience with previous displays and realizing that the subjects were being given more and more practice with moderately well structured strings, one would expect a gradual reduction in the search rates for the more structured displays as they proceeded through each additional block of trials. Similarly, one would expect a gradual inflation in the search rates for the least structured strings since the strategy the subjects were being primed to adopt would not be effective for strings having a minimum amount of structure.

Of course, aside from the issue of whether this priming-effect hypothesis can be clearly substantiated in subsequent research, there are several additional questions that definitely need to be addressed based on the results of this study. First, there is the question of why the letter search tasks failed to capture the subtle differences in orthographic structure revealed in the post hoc comparisons of the subjective ratings. Perhaps the explanation lies in the fact that the subjects needed to be "primed" with a block of practice displays drawn at random from the pool

of displays they would subsequently be asked to search and that each subsequent block of displays should have been composed of an equal number of each type of display, randomly permuted. This paradigm would have been more analogous to that of the rating experiment since each of the four alternate forms of the rating protocol listed all of the strings to be rated in random order.

Secondly, there is the haunting question of whether a different type of between-subjects paradigm might produce a significant effect of orthographic structure on the rate of letter search. Certainly, it seems probable that the between-subjects paradigm adopted in the present study might have produced a significant difference in the search rates through OS and OI-MIN strings had the subjects been more appropriately "primed" for the experimental displays. This possibility could be readily tested by replicating the paradigm using practice displays of orthographically well-structured as opposed to poorly structured strings.

Finally, there is the question of whether subjects can become so well practiced in searching various types of displays that the effect of differences in orthographic structure disappears. Although it is possible that the improvement curves for the various types of displays in the present study may have reached similar asymptotes had the number of trials been increased, it seems more reasonable to assume that their asymptotes would differ, reflecting the overall amount of available structure that could be used to facilitate the subjects' rate of search. Such a finding would provide the evidence necessary to refute the argument that the differences in the results of a between as opposed to a within-subjects design is largely a function of overall task improvement.

References

Aderman, D., & Smith, E. E. Expectancy as a determinant of functional units in perceptual recognition. Cognitive Psychology, 1971, 2, 117-129.

Baron, J. Successive stages in word recognition. In P. M. A. Rabbitt, & S. Dornic (Eds.), Attention & performance, V. New York: Academic Press, 1974.

Carr, T. H., Davidson, B. J., & Hawkins, H. L. Perceptual flexibility in word recognition: Strategies affect orthographic computation but not lexical access. Journal of Experimental Psychology: Human Perception and Performance, 1978, 4, 674-690.

Gibson, E. J., Tenney, Y. J., Barron, R. W., & Zaslow, M. The effect of orthographic structure on letter search. Perception & Psychophysics, 1972, 11, 183-186.

Grubbs, F. E. Sample criteria for testing outlying observations. The Annals of Mathematical Statistics, 1950, 21, 27-58.

Krueger, L. E. Search time in a redundant visual display. Journal of Experimental Psychology, 1970, 83, 391-399.

Krueger, L. E., Keen, R. H., & Rublevich, B. Letter search through words and nonwords by adults and fourth-grade children. Journal of Experimental Psychology, 1974, 102, 845-849.

Krueger, L. E., & Weiss, M. E. Letter search through words and nonwords: The effect of fixed, absent, or mutilated targets. Memory and Cognition, 1976, 4, 200-206.

Lefton, L. A. Probing information from briefly presented arrays. Journal of Experimental Psychology, 1974, 103, 958-970.

Manelis, L. The effect of meaningfulness in tachistoscopic word perception.

Perception & Psychophysics, 1974, 16, 182-192.

Mason, M. Reading ability and letter search time: Effects of orthographic structure defined by single-letter positional frequency. Journal of Experimental Psychology: General, 1975, 104, 146-166.

Mayzner, M. S., Tresselt, M. E., & Wolin, B. R. Tables of single-letter and digram frequency counts for various word-length and letter-position combinations. Psychonomic Monograph Supplements, 1965, 1 (2).

McKay, A. T. The distribution of the difference between the extreme observations and the sample mean in samples of n from a normal universe. Biometrika, 1935, 27, 466-471.

Rouse, R. O., & Verinis, J. S. The effect of associative connections on the recognition of flashed words. Journal of Verbal Learning and Verbal Behavior, 1962, 1, 300-303.

Underwood, B. J., & Schulz, R. W. Meaningfulness and verbal learning. Philadelphia: Lippincott, 1960.

Venezky, R. L., & Massaro, D. W. History's best kept secret about reading. In L. Resnick and P. Weaver (Eds.), Theory and practice of early reading. Hillsdale, N. J.: Lawrence Erlbaum Associates, 1979, in press.

Footnotes

[1]This study was partially supported by a Grant-in-Aid from the College of Education, University of Delaware.

[2]The authors would like to thank David Anderer for assistance in preparing the PLATO letter-search program and Arthur Hoerl for his assistance in identifying the outlying data.

TABLE 1

Mean Search Time Per Item (in Milliseconds)

by Display Type and Block Number

Type of display	Block 2	3	4	5	All blocks
OS	473	457	435	391	441
OI-MAX	483	456	438	419	449
NS	465	441	430	436	443
OI-MIN	453	462	478	439	457
All displays	469	454	445	422	

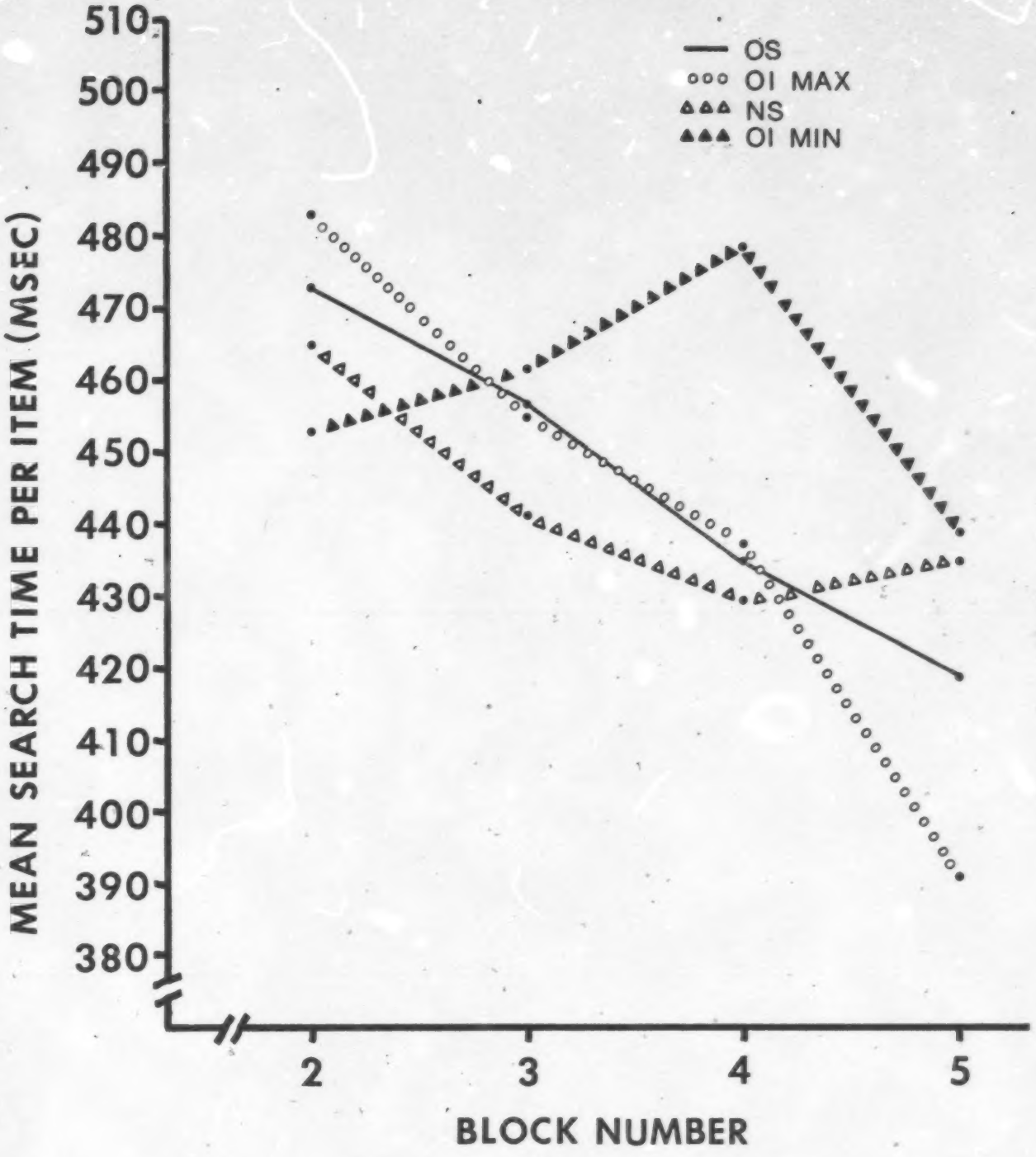
TABLE 2

Mean Error Rate by Display Type

	Type of error		
Type of display	DNF	Line	Outlier
OS	4.64%	.22%	2.97%
OI-MAX	3.55%	.22%	2.61%
NS	4.35%	.29%	1.74%
OI-MIN	4.93%	.43%	2.97%

Figure Captions

Fig. 1. Mean search time per item (msec.) by block number.


OS
OI MAX
NS
OI MIN
MEAN SEARCH TIME PER ITEM (MSEC)
510
500
490
480
470
460
450
440
430
420
410
400
390
380
2
3
4
5
BLOCK NUMBER